

**TABLE OF CONTENTS**

<b>CHAPTER</b>	<b>TITLE</b>	<b>PAGE</b>
	<b>DECLARATION</b>	ii
	<b>DECLARATION</b>	iii
	<b>DEDICATION</b>	iv
	<b>ACKNOWLEDGEMENTS</b>	v
	<b>ABSTRACT</b>	vi
	<b>ABSTRAK</b>	vii
	<b>TABLE OF CONTENTS</b>	viii
	<b>LIST OF TABLES</b>	xii
	<b>LIST OF FIGURES</b>	xiii
	<b>LIST OF ABBREVIATIONS</b>	xvii
	<b>LIST OF SYMBOLS</b>	xviii
<b>1</b>	<b>INTRODUCTION</b>	
1.1	Introduction	1
1.2	Background to The Problem	3
1.3	The Problem Statement	8
1.4	The Aim	9
1.5	The Objectives	9
1.6	The Scope	9
	1.6.1 The Objects	10
	1.6.2 The Datasets	11
	1.6.3 The Hardware and Software	11
1.7	Brief Methodology	12

1.8	Research Workflow	15
1.9	The Thesis Structure	16
1.10	Conclusions	17
<b>2</b>	<b>3D PRIMITIVE OBJECTS AND SPATIAL DBMS</b>	
2.1	Background	18
2.2	Primitive Objects	19
2.2.1	Sphere	20
2.2.1.1	Spherical Coordinates	21
2.2.2	Cylinder	24
2.2.3	Cone	26
2.2.4	Torus	28
2.3	Solid Modeling	31
2.3.1	Decompositions Model	33
2.3.2	Constructive Solid Geometry (CSG)	36
2.3.3	Boundary Representation	37
2.4	Polyhedron	40
2.5	Polygon Orientation	42
2.6	Spatial Database Management System	44
2.6.1	Geometry and Dimension in Spatial DBMS	45
2.6.2	Volumetric Object in Spatial DBMS	46
2.7	Oracle Spatial DBMS	47
2.7.1	Supported Geometry Types	49
2.7.2	SDO_Geometry	51
2.7.3	Interoperability	54
2.8	Summary	55
<b>3</b>	<b>MODELING 3D PRIMITIVE OBJECTS</b>	
3.1	Background	56
3.2	Modeling Objects using B-Rep and Spherical Coordinates	57
3.3	Constructing 3D Primitive Objects	58
3.3.1	Sphere	58
3.3.2	Modeling Solid Sphere	60

3.3.3	Cylinder	68
3.3.4	Modeling Cylinder	70
3.3.5	Cone	72
3.3.6	Modeling Cone	74
3.3.7	Torus	76
3.3.8	Modeling Torus	78
3.4	Conclusion	81
<b>4</b>	<b>THE IMPLEMENTION OF 3D PRIMITIVE OBJECTS AT DBMS LEVEL</b>	
4.1	Background	83
4.2	Implementation Approach	84
4.2.1	Stored Procedure	84
4.2.2	Create Procedure	86
4.2.3	Load Procedure in DBMS	90
4.3	3D Primitive Objects in DBMS	91
4.3.1	Indexing of Spatial Data	93
4.3.2	Creating Spatial Index and Spatial Index Parameter	95
4.3.3	3D Primitive Objects Procedure	98
4.3.4	Volume and Area Calculation	100
4.4	Rotation Element	110
4.5	Conclusion	117
<b>5</b>	<b>RESULTS AND QUERY</b>	
5.1	Background	118
5.2	Visualization of 3D Primitive Objects	119
5.3	3D Primitive Objects in DBMS	119
5.3.1	Cone	121
5.3.2	Cylinder	123
5.3.3	Torus	125
5.3.4	Sphere	128
5.3.5	Half Cone	130
5.3.6	Half Cylinder	131

5.3.7	Half Torus	132
5.3.8	Quarter Torus	134
5.3.9	Hemisphere (Half Sphere)	135
5.4	Rotation Element	136
5.5	Combination of 3D Primitive Objects	145
5.6	3D Primitive Objects and Real Datasets	151
5.7	Query	155
5.8	Surface Smoothness	157
5.9	Conclusion	159
<b>6</b>	<b>CONCLUSION AND RECOMMENDATION</b>	
6.1	Conclusion	160
6.2	Recommendation	164
	<b>REFERENCES</b>	166
	Appendices A-C	173-189

## LIST OF TABLES

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Supported geometry types in Geo-DBMS	42
2.2	Valid SDO_GTYPE values Oracle (2007)	52
4.1	DBMSs and supported programming language for stored procedure (Wikipedia, 2010)	85
4.2	Parameters of 3D primitive objects	93
4.3	Rotation Matrix	111
4.4	Location of rotation point	115

## LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	A procedure to store cube in Oracle DBMS	5
1.2	Missing procedure in DBMS	6
1.3	Polyhedron to construct a cylinder	7
1.4	Missing Objects in DBMS level	12
1.5	Basics syntax for the CREATE OR REPLACE PROCEDURE statement	13
2.1	Several 3D primitive objects	19
2.2	Extended 3D primitives objects	20
2.3	Structure of sphere	20
2.4	Spherical Coordinates	21
2.5	Location of point P by spherical coordinates ( $r, \theta, \phi$ ) and rectangular coordinates ( $x, y, z$ )	23
2.6	Sphere with center $(x_o, y_o, z_o)$ and radius R	23
2.7	Points on sphere with radius r	24
2.8	Structure of cylinder	25
2.9	Right Cone	27
2.10	Simple Torus	28
2.11	Structure of Torus	29
2.12	Location of variable $c$ and $a$ in equation 2.29, 2.30 and 2.31	30
2.13	Location of variable $u$ and $v$ in equation 2.29, 2.30 and 2.31	31
2.14	Location $u$ and $v$ in torus structure with x, y and z plane	31
2.15	Exhaustive Enumerations	34
2.16	Quad tree models	35
2.17	Boolean operations on 3D primitive objects using CSG	37

	method	
2.18	Modeling cube using Boundary Representation method	38
2.19	Baumgart's winged-edge data structure	38
2.20	Right Hand Thumb Rules	43
2.21	Polygon drawn counter-clockwise	43
2.22	Direction of normal surface	44
2.23	Oracle Spatial Components	48
2.24	Geometry type in Oracle 11g	50
2.25	Conceptual class diagram of the SDO_GEOMETRY	54
	data type	
3.1	Location of $\varphi$ , $\theta$ and $r$ on the x,y,z plane	58
3.2	Radius $r$ from centre point of sphere	59
3.3	Polyhedron on the sphere surface (up and bottom)	60
3.4	The degree of round circle is $360^\circ$	61
3.5	Divided sector angle is $\theta = 18^\circ$	61
3.6	New points generated along the latitude	62
3.7	Divided sphere diameter	62
3.8	New latitude with its centre point $x_n, y_n, z_n$	64
3.9	Ten generated latitudes with the origin latitudes	64
3.10	Right triangle is formed after joining all the three points	65
3.11	Triangle in Theorem Pythagoras definition	66
3.12	The right triangle	66
3.13	Complete generated points along the latitudes	67
3.14	Generating Polyhedron from points to model Sphere	68
3.15	Cylinder with height $h$ and radius $r$	68
3.16	Top and bottom surface of cylinder	69
3.17	Body of cylinder	69
3.18	Location of $\varphi$ , $\theta$ and $r$ .	70
3.19	Generated points at the bottom surface of cylinder	71
3.20	Generated centre points for the top and bottom surface of cylinder	71
3.21	Generated Polyhedron from points to model Cylinder	72
3.22	Cone with height of $h$ and base radius of $r$	73

3.23	Collection of face to construct the body and base of cone	73
3.24	Location of $\phi$ , $\theta$ and $r$ for the circular base of cone	74
3.25	Generated point along the cone base	75
3.26	Generated cone from several points	76
3.27	Torus with the main radius of $R_{main}$ and subradius of $r_{tube}$ .	76
3.28	Types of Torus	77
3.29	Constructed torus from rectangle	78
3.30	Collection of polygon faces to construct torus	78
3.31	Circle base geometry for torus	79
3.32	Illustrate the generated points on torus surface based on the centre point and radius $R$	80
3.33	Generated points using sub radius $r$ along tube cross section	80
3.34	Polyhedron to construct torus	81
4.1	PL/SQL in Oracle database server Oracle, 2007	86
4.2	The basic syntax for the CREATE OR REPLACE PROCEDURE statement	88
4.3	Procedure is created in DBMS	90
4.4	MBR enclosing the geometry	94
4.5	Example of R-Tree index for a set of points	94
4.6	Storage of R-Tree spatial indexes	95
4.7	Area and volume value for cone	103
4.8	Area and volume value for cylinder	106
4.9	Area and volume value for torus	108
4.10	Area and volume value for sphere	110
4.11	Rotation on the axis x, y and z	111
4.12	The left-handed orientation is shown on the left, and the right-handed on the right.	112
5.1	Data interoperability through Oracle and Bentley	119
5.2	Retrieved cone datasets through CAD viewer	122
5.3	The Geometry of Cylinder in Bentley Map	125
5.4	Retrieved Geometry of Torus in Bentley Map	127
5.5	Visualization of Sphere	129



5.6	Visualization of half cone from different views	131
5.7	Visualization of half cylinder from different views	132
5.8	Visualization of half torus from different views	133
5.9	Visualization of quarter torus from different views	134
5.10	Visualization of hemisphere from different views	135
5.11	Rotation of cone towards the axis $-x$ $R_x(\theta) = 90^\circ$ (right)	136
5.12	Rotation of cone towards the axis $-y$ $R_y(\theta) = 90^\circ$	137
5.13	Rotation of cone towards the axis $-z$ $R_z(\theta) = 90^\circ$	138
5.14	Rotation of cylinder for axis $-x$ $R_x(\theta) = 90^\circ$	139
5.15	Rotation of cylinder for axis $-y$ $R_y(\theta) = 90^\circ$	139
5.16	Rotation of cylinder for axis $-z$ $R_z(\theta) = 90^\circ$ .	140
5.17	Rotation of torus for axis $-x$ $R_x(\theta) = 90^\circ$	141
5.18	Rotation of torus for axis $-y$ $R_y(\theta) = 90^\circ$	142
5.19	Rotation of torus for axis $-z$ $R_z(\theta) = 90^\circ$	142
5.20	Rotation of sphere for axis $-x$ $R_x(\theta) = 90^\circ$	143
5.21	Rotation of sphere for axis $-y$ $R_y(\theta) = 90^\circ$	144
5.22	Rotation of sphere for axis $-z$ $R_z(\theta) = 90^\circ$	144
5.23	Simulation of tower structure	147
5.24	SALT building structure SAOO (2010).	148
5.25	Simulation of SALT building	149
5.26	Simulation of pipeline in various directions	150
5.27	Real datasets of building tower in Suleymaniye area	151
5.28	The real image (left) and the constructed tower using 3D primitive objects with cube and faces (right)	153
5.29	Image of the experimented object	154
5.30	Dome in the AutoCAD format (left) and rendered datasets from DBMS (right)	155
5.31	Retrieved record from DBMS through SQL function	157
5.32	Different Level of Surface Smoothness on Torus	158

## LIST OF ABBREVIATIONS

2D	-	Two-dimensional
2.5D	-	Two-and-a-half-dimensional
3D	-	Three-dimensional
CAD	-	Computer Aided Design
GIS	-	Geography Information System
DBMS	-	Database Management System
SQL	-	Structured Query Language
CSG	-	Constructive Solid Geometry
B-Rep	-	Boundary Representation
PL/SQL	-	Procedural Language/Structured Query Language

## LIST OF SYMBOLS

$A$	-	area
$A_{\text{sphere}}$	-	surface area of sphere
$A_{\text{cylinder}}$	-	surface area of cylinder
$A_{\text{cone}}$	-	surface area of cone
$A_{\text{torus}}$	-	surface area of torus
$A_{\text{without top or bottom}}$	-	surface area without the top or bottom
$A_{\text{with top or bottom}}$	-	surface area with the top or bottom
$T_{\text{cylinder}}$	-	total surface area of cylinder
$\pi$	-	$\pi = 3.142$
$r$	-	radius
$R_{\text{main}}$	-	radius from the center of the hole to the center of the torus tube
$R_{\text{tube}}$	-	radius of the tube
$V$	-	volume
$V_{\text{sphere}}$	-	volume of sphere
$V_{\text{cylinder}}$	-	volume of cylinder
$V_{\text{cone}}$	-	volume of cone
$V_{\text{torus}}$	-	volume of torus
$\theta$	-	angle
$\varphi$	-	azimuth
$h$	-	height
$s$	-	cone side/slant height
$c$	-	$c$ is the radius from the center of the hole to the center of the torus tube
$a$	-	$a$ is the radius of the tube
$u$	-	angle of torus longitude
$v$	-	angle of torus latitude
$D$	-	Diameter of sphere